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ON

REMAINS OF A CYATHASPIS

FROM

THE SILURIAN STRATA OF GOTLAND

BY

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WITH TWO PLATES.

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In the autumn of 1894 a very skilled fossil collector, A. Florin, sent to the Palæontological Department of the State Museum in Stockholm a few remarkable fossils, which he had found in the shale beds of Gotland. They consist of two nearly complete shields (scuta) and of some fragments and scales of a Cyathaspidian fish, as could be seen without difficulty in consequence of their perfect state of preservation.

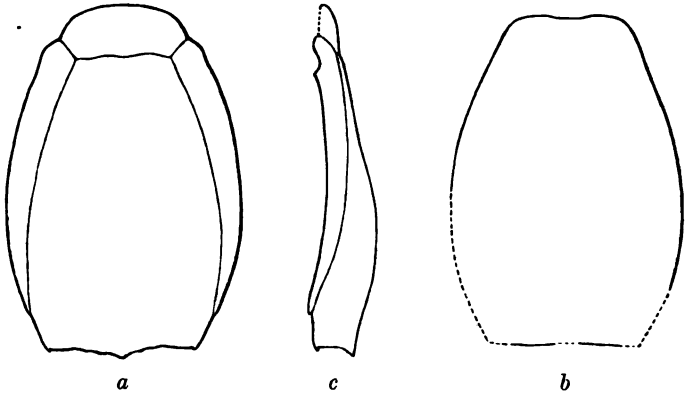


Fig. 1.

a. Outlines of the dorsal scutum, nat. size.
b. Ditto of the ventral scutum, nat. size.
c. Side view of the left cornu with the eye-notch; the scutum seen behind.

The two complete shields have the common Cyathaspidian shape, somewhat oval or elliptical, truncated anteriorly and with the posterior end emarginated. Their external surface is of a peculiar silky lustre, glossy, as of enamel. One shield, no doubt the dorsal scutum, is composed of four different and distinct parts, a rostral plate, a central disc, having on each side a narrow plate, the so called cornua. Through the direction of the ridges, which cover the surface, these cornua are easily distinguished as separate from the central

disc and, moreover, through faint traces of partition lines. In a vertical section, across these lines, they are not discernible below the surface, but have interiorly coalesced with the central disc, so as to form a single, solid piece (Pl. II, fig. 2 & 3 x).

The rostrum is transverse, with the anterior margin arched, the posterior one forming a curved or wavy line.

The large central disc is anteriorly narrow and widens towards the posterior margin, where it is protracted into a short and blunt central spine.

The lateral plates (cornua) are narrow, broader anteriorly, tapering off backwards and ending in a small sharp point. Their edges are inflected towards the interior surface and in consequence the glossy ridges continue a little below on the inferior surface. When seen from the sides they show near the anterior margin a shallow notch, which may have formed the upper part of the orbit (Pl. I, fig. 4).

The ridges of the surface are generally parallel to the longitudinal axis of the plates which they cover. Thus in the rostral plate they are transverse or go in a direction at right angles to the ridges of the hindermost plates. Seldom, excepting on the narrow cornua, can a ridge be seen continuing without interruption the whole length of the plate. They cease or are intertwined with other or are dissolved, as it were, in groups of small tubercles or knobs. As several authors have most appropriately said, their general appearance reminds one of the markings of the epidermis on the palm of the human hand. On the large central disc is remarked a very distinct triangular area, having its base towards the anterior margin and its apex backwards. The ridges there form irregular whorls and are dissolved into a small group of tubercles, like a sort of pavement.

The interior surface, or that which must have rested immediately upon the soft organic tissues, (Pl. I, fig. 12) by which it has been secreted, is, as far as may be seen from the detached fragments, smooth, of a sombre colour, and is covered with innumerable microscopical openings of narrow tubes or ducts, which perforate the shell substance. It is moreover divided into polygons by minute lines, no doubt corresponding to the partition walls of the vacuoles mentioned below and which form the chief mass of the shield.

It is probable that the central disc in this specimen, alike the others previously found in Germany and Galicia, is provided on its interior surface with paired impressions of the gills on both sides and of the peculiar organs situated anteriorly on the median linie. One of these is by some authors regarded as a parietal eye and perhaps it corresponds with a prominent little tubercle on the exterior surface in the middle of the triangular area.

The second specimen (Pl. I, fig. 5) is a little smaller, also of an oval shape, but consists of only one piece. There is consequently no rostrum, nor is there any probability that there has been a deciduous one, as the anterior margin shows no indications of a rupture. A narrow triangular space with irregular ridges is situated close to the anterior margin, by no means attaining so large a size as in the dorsal shield. It is highly probable that this smaller shield has been the ventral one of the same specimen, as it in its general shape so well corresponds with this, as also with those from previously known species.

Along with some other fragments was found, detached and broken into three pieces, what may be regarded as the shelly covering of an extremity or limb (Pl. I, fig. 9—12). It is plain that it is not a fragment of the dorsal shield nor of one of the cornua. Its exterior ridged surface is, to wit, inflected towards the interior surface along the lateral edges and partly covers it. In all probability the muscular and other organs, which it has covered, were in the same way sheltered on both sides by similar plates. It is narrow, elongated, by degrees tapering and ending bluntly. The surface is of the same glossy lustre as the other portions of the exoskeleton and is covered with ridges which have a nearly parallel direction and continue without interruption. On the interior surface (Pl. I, fig. 12) which is quite smooth, are seen the polygonal partition lines of the vacuole walls and the openings of the minute canals. There is no evidence that it has consisted of more than one plate, nor that the supposed extremity has been covered by several plates, as the limbs of Pterichthys.

On the slab bearing the dorsal scutum there lies a scale, (Pl. I, fig. 6—7) broken at one side, what shows that it has been a little longer than at present. It has the same glossy surface as the shields and is transversally protracted into a

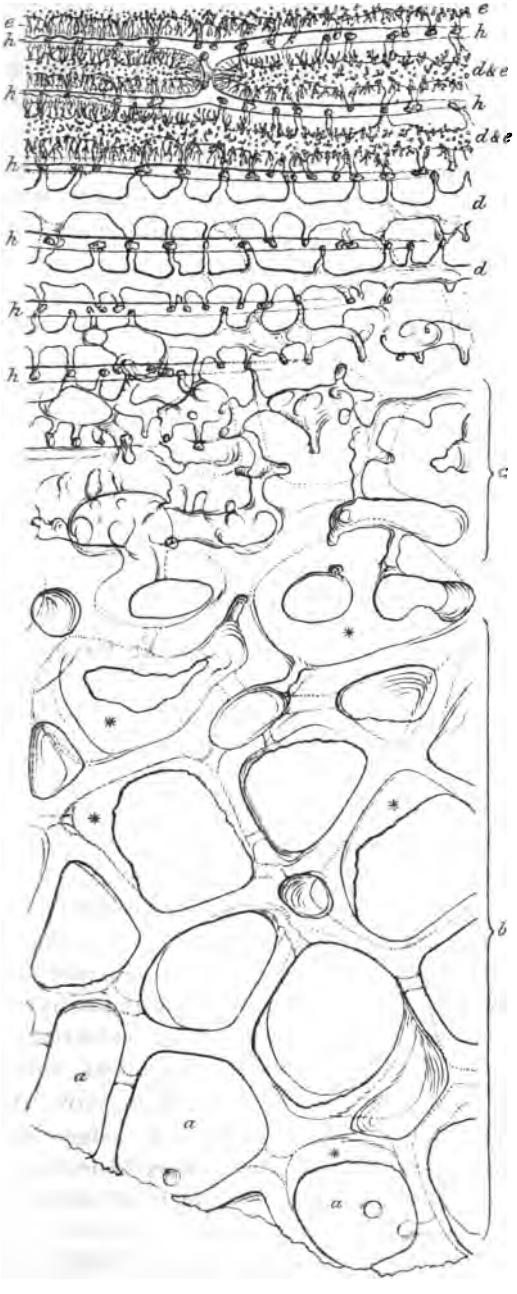
rhomboid shape with ridges divided into two fields, a narro one at right angles to a larger on which the ridges descen giving the whole a certain likeness to a comb. These ridg are of the same structure as the ridges of the scutum. Th inferior margin is arched outwards, while the superior i curved inwards. Besides this scale there is on the same sla an impression (Pl. I, fig. 8) of a larger scale which seems to hav been lying in its original place, behind the dorsal scutu in the tail.

The dimensions of the different shields and their com ponent parts are as follows.

The dorsal shield.

Length	47	mm.
Breadth at anterior margin	13	mm.
» across the middle line	30	mm.
» at the posterior margin	20	mm.
Dimensions of rostrum	6 × 15	mm.
» of central plate	40 × 25	mm.
Length of the most complete side plate	34	mm.
Breadth of same	5	mm.
Thickness of the shell	1	mm. at the most.
The total length of the ventral shield	44	mm.
Greatest breadth	29	mm.
Breadth at rostral margin	14	mm.
Dimensions of the scale	4 × 9	mm.
Length of the supposed limb	25	mm.
Greatest breadth	6	mm.
Thickness, nearly	1,5	mm.

As to the histology of this exoskeleton it may be said, that the different strata that can be discerned are by no means distinctly separated from each other, they are rather in uninterrupted continuation, or, as it were, modifications of one and the same stratum. The interior part consists of finely laminated strata of various shades of colour some darker, others lighter, and these pass imperceptibly upwards to form the partition walls between the large vacuoles. which constitute the second stratum or the main of the shell. The basal stratum (Pl. II, fig. 1—4, a) is perforated by narrow tubes, some straight, others winding, which osculate both interiorly towards the cuticulum of the animal, and into the large vacuoles and thus have formed ducts between the



Signification of the letters.

a. Basal stratum.
b. Vacuole stratum.
c. Haversian canals.
d. Pulpa canals.
e. Dentine tubes.
h. The open grooves between the ridges.
* Fragments of partition walls.

The dotted lines are the contours of ducts and canals lying under the surface of the transparent section.

Fig. 2.

Oblique section of portion of the scutum, crossing all its strata.

cuticulum and the vacuoles, no doubt for the fluid or semi-fluid mass which filled these (Pl. II figs 1—4 b). The vacuoles are comparatively large and are closed polygonal cavities without any distinct separation between the walls of the contiguous ones.

They are in communication with each other through transverse tubuli, which perforate the walls. Upwards the vacuoles communicate through such ducts with a network of larger canals (Haversian canals according to ROHON) which run in a direction transverse to that of the ridges. These canals again are connected with a stratum of other canals (Pl. II, figs 1—4 e) which lie above them and go in a direction at right angles to them and parallel to the ridges of the exterior surface, just a little below them. There is one such longitudinal canal to each ridge. From them an immense number of minute ramifying tubuli (Pl. II, figs 1—4 f) issue, filling the uppermost stratum and ending near the surface of the ridges without any distinctly apparent opening. These are the dentine tubes, as the authors describing other Pteraspidians have called them. The canals, from which they issue, then are homologous to the pulpa cavity and may be called »*pulpa canals*».

There are thus in all five different kinds of canals traversing the exoskeleton, viz. 1, the ducts in the basal stratum. 2, the communicating tubes between the vacuoles, 3, the »Haversian canals», 4, the »pulpa canals», and 5, the dentine tubuli.

It is probable that the glossiness of the surface is due to an extremely thin covering of enamel, imperceptible in all sections through its extraordinary tenuity.

As to the ridges they are provided with one sharp, thin, prominent ledge (Pl. II, fig. 1—3 h), running all along one of their sides and with two such ledges opposite. The solitary ledge is finely crenated. A few ridges have only one ledge on each side, and these are both crenated (Pl. II, fig. 5). On the central disc of the dorsal shield the double ledges are directed inwards, while on the cornua they are directed outwards and again change their position on the inflected side, where this turns round to the inferior surface.

Between each pair of ridges an open groove (Pl. II, figs 1—3, i) circular in its section, runs parallel to them, in connec-

tion with the ambient medium only through a narrow slit-like opening left between the opposite ledges of the adjoining ridges.

There can be no doubt that these interesting relics belong to the Cephalaspidæ in HUXLEY's [1]) conception or to the family of the Pteraspidæ in the subclass of Ostracodermi, ordo Heterostraca, according to A. SMITH-WOODWARD. [2])

In comparing this Gotland fossil with others previously known there is none with which it may more aptly be identified than with Cyathaspis Schmidtii, described by Prof. E. GEINITZ, [3]) who had the kindness to send me casts of his specimen. It is a little smaller than mine, but the shape of the scutum and the arrangement of its component parts as well as the form of the ridges so nearly coincide in both, that the trifling differences as to size may have value only as marking varieties. How far these specimens — the German and the Swedish — may be justly included in the genus Cyathaspis must depend solely upon future discoveries, showing that the English and other foreign species constituting the genus Cyathaspis, have a histological structure similar to that of my specimen. So far as I am aware there does not exist a single figure of any section published, showing the microscopic structure of the scutum in the English and Galician specimens. Dr JAEKEL of Berlin has kindly told me that »Pteraspis» integra of KUNTH comes very near to my specimens in respect of the structure of the ridges, which is quite different from that which prevails in the English species of Pteraspis as may be seen by comparing with them the figures given by LANKESTER [4]) and as also sections I have taken from such specimens show. »Pteraspis» integra differs, however, so much from Cyathaspis and still more from Pteraspis that Dr JAEKEL considers it to form a new generic type. Some uncertainty must also prevail as long as it is not known whether or not the specimens of Cyathaspis Schmidtii are marked on the interior surface of the dorsal scutum with

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[1]) Memoirs Geol. Survey Un. Kingdom, British Organ. Remains, Decade X, p. 38.

[2]) Catalogue of the Fossil Fishes in the British Museum, pt II, p. 159.

[3]) »Ueber ein Graptoliten-führendes Geschiebe mit Cyathaspis von Rostock» in Zeitschrift der Deutschen geologischen Gesellschaft 1884, p. 854.

[4]) Monograph of the Fishes of the Old Red Sandstone of Britain, pt I plate VII, figs 1—7.

impressions of paired branchial grooves and with the pineal pit environed by two cuneiform impressions on each side, as in the English and Galician species.

In the Russian island of Oesel some fossil fishes have been found which in the shape and structure of their scales come very near to the Gotland form. PANDER's description and figures [1]) of his Tolypelepis nearly coincide with it. His figures of the surface (Pl. 6, fig. 24 a—b are nearly like it); fig. 24 c. represents, although somewhat roughly, the numerous small tubuli which lie close under the surface (compare my figures 5 & 6, Pl. II) and fig. 24 d gives a view of the prisma like vacuoles. On turning to PANDER's descriptions it is evident that he intended to describe the same structure as is found in my specimens. Lately ROHON [2]) has published excellent figures of the microscopic structure in this genus, to which FR. SCHMIDT has given the new name of Tolypaspis. Though having the superficial ridges nearly resembling those of Cyath. Schmidtii it, however, in the said structure differs much more from this, than does the Oniscolepis dentata. [3]) But this again is more irregularly built and as to the ridges resembles the sections of Pteraspis, although the ridges are broader than in the last mentioned genus.

The geological age, to which this Cyathaspis belongs, may be best settled by a review of the organic contents of the stratum which encloses it. This stratum is situated in the south eastern parts of Gotland, in the parish of Lau, where during the last few years a canal is being cut in order to drain the marshy grounds on the plateau a little to the south-west of the church of Lau. The uppermost limestone beds which form the hills round the church are rich in fossils and, especially, are known to contain the curious operculated coral Rhizophyllum gotlandicum and others. These beds are denuded towards the south near the small lakes of Lau where there is an outcrop of a soft gray, marly shale, forming the underbed, as almost everywhere in Gotland. The fossils contained in the shale beds are enumerated below.

Pisces. Cyathaspis? Schmidtii E. GEINITZ.

[1]) Monographie der fossilen Fische des silurischen Systems der Russisch-Baltischen Gouvernements, p. 60.

[2]) Die Obersilurischen Fische von Oesel. II Theil. in Mém. Acad. Imp. des Sciences de St. Petersbourg, VII:e Série. T. XLI, N:o 5, pl. II, fig. 56.

[3]) L. c. pl. III, f. 59.

Crustacea. Phacops Downingiæ MURCHISON, Chirurus speciosus DALM., Encrinurus punctatus WAHLENBERG, Calymmene frontosa LDM., Cal. excavata LDM., Acidaspis n. sp., Proetus conspersus ANG., Proetus sp., Bumastus sulcatus LDM. — Pterygotus sp., Emmelozoë Lindströmii R. JONES, [1]) Leperditia phaseolus HIS., Leperd. sp., Beyrichia, four species, one very large, Bythocypris, two species.

Annulata. Autodetus calyptratus SCHRENK, Tentaculites, Trachyderma sp., tubes of two other different species of Annelida.

Cephalopoda. Gomphoceras plicatum Mus. Holm, Phragmoceras sp., four species of orthoceratites in bad state of preservation.

Pteropoda. Conularia lævis, var. costata LDM, Conul. delicatissima Mus. Holm.

Gastropoda. Palæacmæa sp., Platyceras cornutum HIS., Bellerophon sp., Pleurotomaria Lloydii LDM, Loxonema sp., Horiostoma coronatum LDM, Cyclonema carinatum SOW., Rhaphidostoma sp.

Lamellibranchiata. Aviculopecten Danbyi M'COY, Pterinea sp., Cypricardinia sp., Ambonychia sp., Ctenodonta sp.

Brachiopoda. Lingula, three species, Discina, Dinobolus, Pholidops implicata SOW., Spirifera Schmidtii LDM, Spirifera sulcata HIS., Atrypa reticularis L., Atrypa sp., Rhynchonella deflexa SOW.?, Rh. sp., Orthis hybrida SOW., Orthis rustica var., Strophomena ornatella SALTER, three other new species of Strophomena, Chonetes sp.

Bryozoa are represented by several species of Fenestella, Ptilodictya and Monticulipora.

Crinoidea, there are detached joints and plates of the stem und crowns of several species.

Anthozoa. Pholidophyllum tubulatum SCHLOTH. and a species of Syringopora.

Graptolites. A species of Dictyonema.

It must be remarked that the corals, so numerous in other strata, are represented here by two species only, scarce in individuals, and that the majority of the other fossils have a very thin and membranaceous shell, even such species, as in other localities are provided with a hard calcareous

[1]) My old friend, Prof. RUPERT JONES writes that he is going to describe his phyllopod, being a new one, under that name.

shell. These two circumstances, taken together with the fine and muddy nature of the shale beds, point to the conclusion, that there was a sheltered bay of the Silurian sea, where in the calm water with muddy bottom a fauna flourished rich in thin-shelled animals. The corals could not thrive well in a water so dissimilar to their usual abode, in the swell of the open ocean.

This fauna is in direct continuity and concordance with the faunas contained in the shale beds north and south of it, those at Östergarn and those of Grötlingbo in the south. Thus Phacops Downingiæ is a form typical for the strata of south Gotland, as well as Chirurus speciosus. Calymmene excavata occurs also in the limestone above the shale beds, and Calym. frontosa links them with the shale of Hablingbo on the west coast of Gotland, Prœtus conspersus occurs as well in Östergarn as in Bursvik.

The most characteristic fossils in the Lau strata are the two Conulariæ and the shields of the little Eumelozoë which in great numbers abound in the beds.

Judging by the position of this shale under the horizontal limestone beds and by its continuity with the beds all around it, it must belong to the age of the Wenlock shale or correspond to it, as the limestone beds nearest above it are of the Wenlock limestone age, and upwards pass into strata showing the character of the Ludlow beds.

It was at first thought that these remains of fossil fishes were the oldest Silurian ones known in consequence of their occurence so low down in the series. CLAYPOLE, [1]) however, insists that he has found remains of fishes so low down as in the American Clinton group which according to him is coëval with the English Upper Llandovery. When I wrote the preliminary note of the discovery of these Gotland fossils. [2]) I was not aware of his paper, nor of a memoir by Dr ROHON, [3]) in which he describes some fossil fish teeth from a still lower level, the Lower Silurian strata called the Glauconite sand near S:t Petersburg in Russia.

Besides this Cyathaspis? Schmidtii there have been found in the shale beds of the same age, but some miles further

[1]) Qu. Journal Geol. Soc. 1885 p. 56, and also »Nature» vol. 52, 1895, p. 55.
[2]) Geol. Magazine 1895, p. 170.
[3]) Ueber untersilurische Fische 1889.

north at Hammarudd in the parish of Kräklingbo, a few scales of two other species. VOLBORTH found them in 1860 [1]) and they were described by ROHON [2]) under the names of Thelolepis parvidens AG. und Thelolepis Volborthi ROHON. The same also occur in Russia and in England.

[1]) Qu. Journ. Geol. Soc. 1861, p. 552.

[2]) Die obersilurischen Fische von Oesel, Mém. Ac. Imp. des Sciences de S:t Petersbourg. VII Ser. Tome XLI, N:o 5, p. 76.

Explanation of Plates.

The signification of these letters is identical in all figures.

a Interior or basal stratum (nacreous lamellæ of A. SMITH-WOODWARD die Osteoide Schicht of ROHON).
b The vacuole stratum (middle substance with cavities HUXLEY, prismatic layer SALTER, middle cancellated polygonal cells LANKESTER Mittlere Schicht ZITTEL, polygonal cancellæ S. WOODWARD, Medullarräume ROHON).
c Partition walls between the vacuoles.
d Haversian canals according to ROHON.
e Pulpa canals.
f Dentine tubuli (Reticular layer with diverticula HUXLEY, External finely striated layer LANKESTER, Dentinrörchen ZITTEL, vaso-dentine S. WOODWARD, Dentin ROHON).
g Enamel ridges of the exterior surface.
h Crenated ledge of a ridge.
i The open grooves between the ridges.

Plate I.

Fig. 1. The dorsal scutum, magnified $^2/_1$. The faintly shaded portion of the rostral plate lies under the anterior edge of the ventral shield. The pointed lines to signify the presumed hidden outlines of the shield.

Fig. 2. Part of the same, where the rostral plate, the central disc and the left cornu meet. $^6/_1$.

Fig. 3. The right posterior end * of the dorsal scutum, from the side, also with the posterior end of the right cornu **, $^4/_1$.

Fig. 4. Anterior part of the left cornu, showing the notch of the orbit. $^4/_1$.

Fig. 5. The ventral scutum. $^2/_1$.

Fig. 6. Scale in natural size.

Fig. 7. The same magnified. $^4/_1$.

Fig. 8. Impression of another scale, nat. size.

Fig. 9. Exoskeleton of a limb. $^2/_1$.

Fig. 10. Section of the larger end of the same.

Fig. 11. Section of the narrow end of the same.

Fig. 12. Part of the interior surface of the same, showing the tubes and basal lines of the vacuole walls. $^8/_1$.

Plate II.

Fig. 1. Transversal section af the left edge of a cornu, nearly 12 mm. behind the orbit, magnif. $^{60}/_{1}$. Same specimen as fig. 4, pl. I.

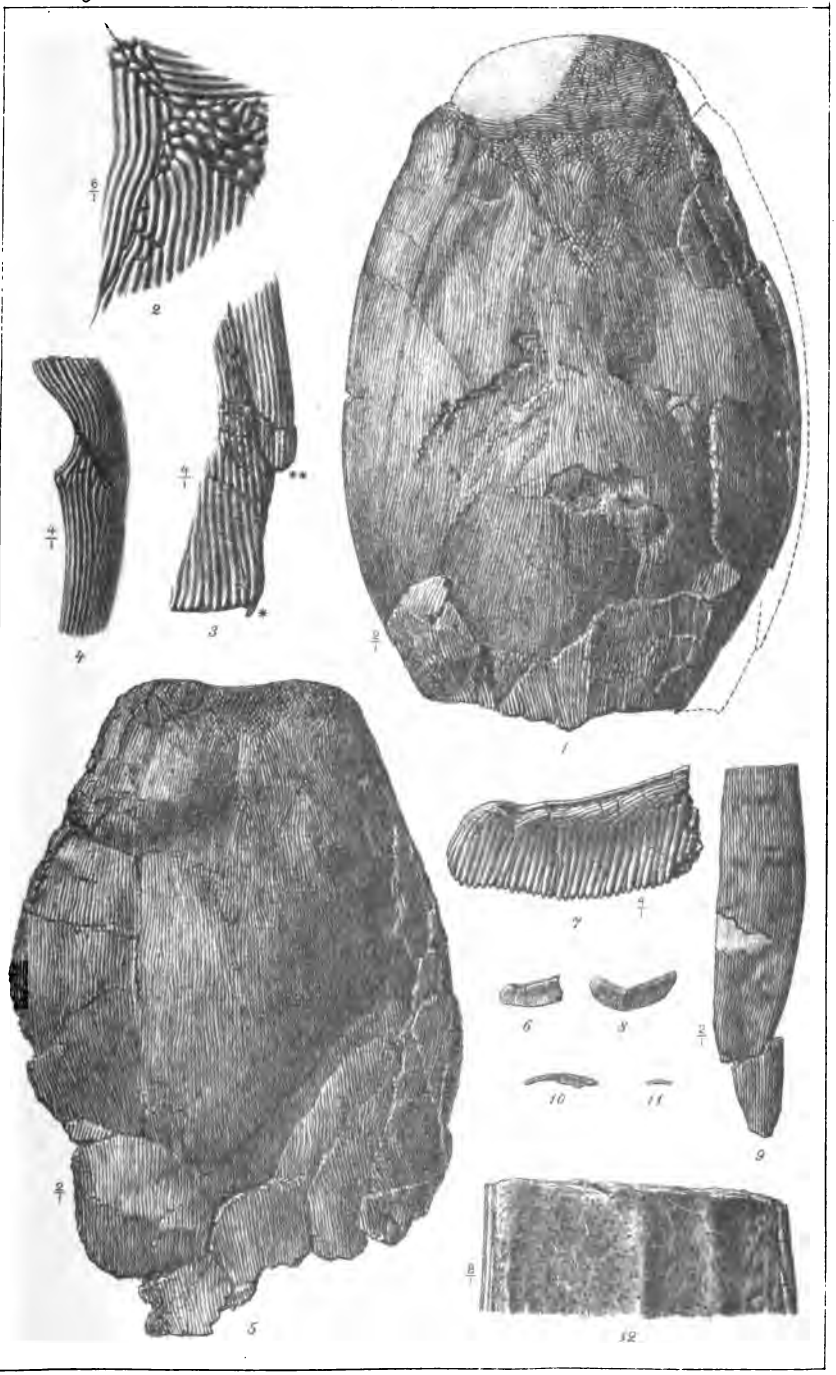
Fig. 2. Transversal section, showing the point where the central disc and the cornu meet at x.

Fig. 3. Transversal section, showing the same point as in fig. 2. Magnif. $^{60}/_{1}$.

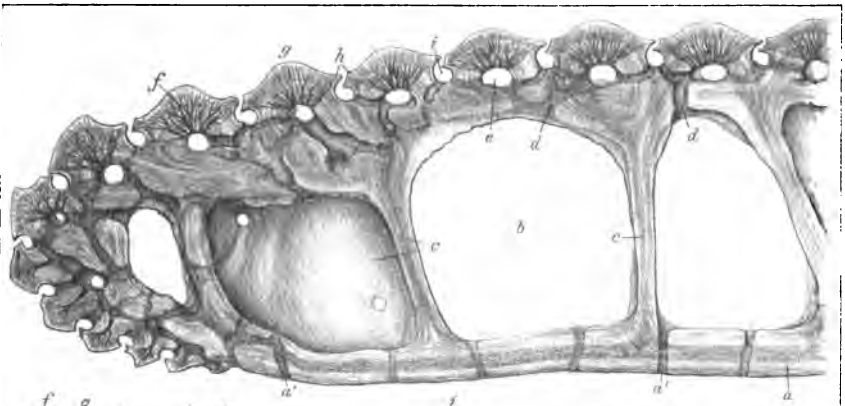
Fig. 4. Longitudinal section parallel to a ridge. Magnif. $^{60}/_{1}$.

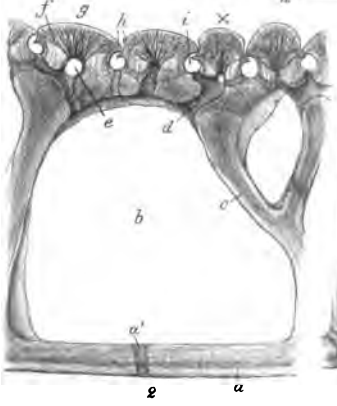
Fig. 5. Horizontal section through a ridge, both ledges crenated, magnif. $^{60}/_{1}$.

Fig. 6. Portion of the preceeding section, magnified. $^{300}/_{1}$.



G. Liljevall. del. & lith. W. Schlachter, Stockholm.





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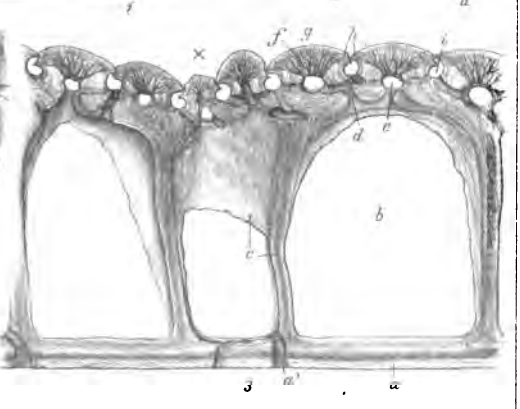

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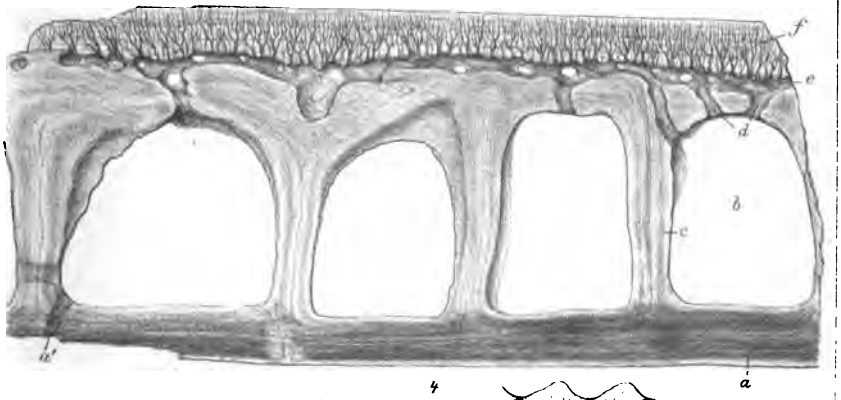

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